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Effect of obturators on facial form following surgery for head and neck cancer and impact on the perception of appearance.

ABSTRACT

Objectives:- To describe the correlation between changes in the surface area and depth of the face in individuals wearing an obturator compared with it not being in place, and self-reported Quality of Life in relation to appearance.

Methods:- Difference images were created from stereophotogrammetry images recorded from research participants with and without their obturators in place. On the difference images of the face, surface areas and mean depths were calculated. Oral health impact profile questionnaires (OHIP-49) were completed.

Results:- Data from 19 research participants were recorded. The mean size of the outlined area of the face when the obturators were present compared to when they were not was 1411mm^2 ($SD \pm 848$). Similarly the mean depth differences ranged up to 6.14mm. Although a proportion of the individuals reported effects in relation to their quality of life, there were no statistically significant relations between the surface areas and mean depths with the participants' responses to the quality of life questions.

Conclusions:- There are clear changes in facial tissues, both in relation to surface area and depths when obturators are worn compared to when they are not. There is no simple relationship between the extent of facial change with and without an obturator and quality of life around appearance. The determinants of changed quality of life in this group of patients require greater exploration.

CLINICAL SIGNIFICANCE STATEMENT

Obturators have effects on the form of facial tissues in relation to surface area and depths, when they are worn compared to when they are not. However it is not precisely clear how quality of life in relation to appearance might specifically be linked to facial form.

INTRODUCTION

Individuals who have had maxillectomies in the midface region can be profoundly affected by changes in masticatory ability, oral function, speech, swallowing and appearance. As well as the restoration of masticatory function with obturators [1], rehabilitation of the defect should aim to minimize facial deformity [2]. Although there are surgical techniques for reconstructing the defects with composite free flaps [3], this is complex which means that either some patients may not be suitable because of general health issues or the expertise to undertake such procedures may not be available in all surgical units. Therefore many individuals who have had maxillary resections are still restored using conventional removable obturators. These are often challenging for people to wear, as, due to their size and often compromised retention, they may not be entirely stable in function, which might impact on leakage and speech, particularly if the individual is edentulous in the maxilla.

Quality of life has been defined as the degree of well being felt by an individual [4]. Many studies have been undertaken to assess the quality of life of individuals following maxillectomy procedures [1,5,6,7,8,9,10]. It seems the case that many factors will impact on the quality of life after surgery, including radiotherapy [2,9], chewing ability [1], and the anatomical location of the resection [10]. Two studies found no obvious difference in health related quality of life scores at one year in individuals who had received flap reconstructions compared with obturator rehabilitation [5,8]. A meaningful quality of life can result with good obturator function [4,6]. Furthermore, a longitudinal study carried out in maxillectomy patients wearing obturators found overall favourable outcomes in relation to quality of life [7].

All of the studies reporting on patient outcomes using quality of life questionnaires cover a range of areas such as oral function, speech, swallowing, appearance and social effects. One particular issue however is facial appearance which might well change significantly not only because of the surgery itself, but also whether the subjects are able to effectively wear their obturators. Until recently the effects of obturators on facial appearance have been difficult to assess because opinions have been based subjectively on what clinicians observe or how the individual reports this. However, in a recent piece of work images were recorded of subjects with and without their obturators in place using a stereophotogrammetry technique, and it was possible to show that overlaying and registration of the separate images was consistent and reproducible [11]. This allowed the effect of obturators in restoring facial volume to be measured and therefore provided some objective evidence on their efficacy in providing facial support.

Surgical removal of bony structures will impact on the facial soft tissues by leaving them unsupported. This may result in the overlying tissues dropping back resulting in a change of appearance, which may be obvious not only to the individuals themselves but to others with whom they interact. There are therefore two aspects as to how an obturator might restore facial form. The first concerns the overlying area of the facial soft tissues, which might have changed following surgery. The second concerns the depths by which unsupported facial tissues could be restored to a more normal contour when the prosthesis is in place. Therefore the objective of this study was to describe the correlation between changes in the surface area and depth of the face in individuals wearing an obturator compared with it not being in place, and self-reported Quality of Life in relation to appearance. The oral health impact profile

(OHIP-49) is a reliable index to look at the social impact of oral disorders [12] and has been used in many studies for people wearing removable appliances [e.g. 13,14,15]. As there are a number of questions that relate to appearance and its effects on individuals, this seemed the most suitable questionnaire to use for the present study.

METHODS

Twenty research participants from three units in England and Scotland were recruited to the study who had all received resections for a range of lesions affecting primarily the maxillary region. Ethical approval was secured from Kings College Hospital Research and Development Committee, Guys Hospital Research Ethics Committee and Tayside Committee in Medical Research Ethics (NHS National Research Ethics Service). A stereophotogrammetry 3D image capture and analysis system (Dimensional Imaging – Glasgow, UK) was used to map the face. The mapping involved recording a photograph of the facial tissues by the use of four linked cameras to capture simultaneous pictures of the research participants. This enabled three dimensional surface images to be produced. One set of images was recorded with the research participants wearing their maxillary obturator and the second set when they had removed it. Details of how the participants were seated and the accuracy of the system [11] is described by Coward et al (2019).

An account of how the stereophotogrammetry images were converted and displayed as a colour coded single difference image to show facial changes resulting from wearing an obturator has also been given in detail [11] by Coward et al (2019). This involved loading the two images of the subject with and without the obturator. Suitably stable areas of the face which would not be likely to change between the two images were identified for registration of points so the two images could be compared. These areas were located on the forehead, midface (depending partly on the clinical location of the lesion which was excluded – see below) and lower face as shown in yellow in Figure 1A. Areas that were judged to be insufficiently stable

between the images (hair, neck, orbits and ears) were identified and shaded orange so that they could be excluded from the registration process (Figure 1A). The area in which the resection had taken place and where the obturator was thought to be having an effect on the facial tissues was also excluded from the registration process itself by again shading the area orange (Figure 1A – mid face area). Registration between the two surfaces was then achieved, on the remaining normal areas of the face (shaded in yellow) which formed the majority of the surface of the image, using an iterative closest point algorithm [16,17]. At each iteration, 500 points on the normal, yellow shaded part of the surface were randomly picked for calculating the next registration error correcting vector, and the correcting vector applied.

A colour coded difference image was then calculated (Figure 1B) to show the differences between the superimposed images of the research participants with and without their obturators in place. This showed the differences between the overlaid images of the individuals, particularly in relation to the defect area which had been restored by the obturator. In this study interest was focused specifically on the area of this defect over the face and the depth that had been restored by the obturator. The scale of the difference image was set up to give maximum resolution but also to ensure that difference values were not beyond the range such that they became outliers and therefore excluded from the analysis. The distribution of depth differences was calculated by creating a 64 bin histogram from small patches (pixels) of the difference surface. In most participants this could be undertaken by using incremental bin widths of 0.25mm which generated a scale of ± 8 mm. However, in a small number of cases where the defects seemed to be particularly extensive and in which the obturators appeared to be having a large effect on facial form, the bin

widths were changed to a lower resolution of 0.5mm which produced a scale of $\pm 16\text{mm}$ (Figure 1B). The generated pixels were stored in the bins which indicated various depths where change took place when the obturator was inserted compared to when it was not present.

On the difference image the defect was outlined separately on two occasions and surface area and depth measurements recorded. In addition the whole process was repeated on a separate set of registrations. This gave a total of 4 surface area and depth measurements for each participant – two from the first registration and two from the second. The mean of the four measurements was used [11] as described by Coward et al (2019) to determine the surface area and mean depth differences restored by the obturators.

The research participants were asked to complete an oral health impact profile questionnaire (OHIP-49) which related to their quality of life. These questions are shown in Table 1. This questionnaire explores a series of domains including function and social interactions but in the context of the present study there are a number of questions specifically related to appearance and related factors. These were as follows:- (i) did they feel their appearance was affected (Question 4); (ii) had they been self-conscious (Question 20); (iii) did they feel uncomfortable about appearance (Question 22); (iv) did they avoid smiling (Question 31); (v) had they been embarrassed (Question 38). There were five possible responses to each of these five questions which in relation to the experience of the research participants were:- (i) never; (ii) hardly ever; (iii) occasionally; (iv) fairly often; (v) very often. The research participants could also choose to answer that the question was not applicable.

Data from the questionnaires was counted and converted into percentages. A Spearman's Rank Correlation Coefficient was used to make comparisons of the quality of life scores from each item with the changes in surface areas and mean depths of the facial tissues restored by the obturators. To account for the simultaneous multiple comparisons a Bonferroni correction was applied to the α level of Type I error of each single test. This meant that the usual p value accepted to suggest significance was modified from its generally set value of < 0.05 to a value of < 0.00051 [18, 19].

RESULTS

Of the total of 20 research participants who were recruited to the study, 19 completed the quality of life questionnaires and so the study will report the results of these only. These were the same individuals recruited in a previous study [11] by Coward et al (2019). There were 9 male and 10 female subjects. The ages of the research participants ranged from 40 to 84 years with a mean of 68 ± 11 years. The participants had previously been treated for a range of lesions affecting the maxilla including ameloblastoma, leiomyosarcoma, adenoid cystic carcinoma, osteosarcoma, chondrosarcoma, basal cell carcinoma and squamous cell carcinoma. Resections of part of the maxilla had been undertaken in all of them and, in addition, some had received radiotherapy and / or chemotherapy. All research participants required a removable prosthetic obturator to restore form and oral function in relation to appearance, mastication and speech. However, there was variation between the individuals on the location and magnitude of the surgical resection and whether it had been possible to retain any natural maxillary teeth. There was also variation between the research participants as to when the surgery was undertaken in relation to the time the stereophotogrammetry images were recorded and for how long they had worn their existing obturator.

An example of the effects of an obturator in restoring facial form is shown in Figure 1. The research participant had received an anterior maxillary resection and the difference image is displayed with a scale of $\pm 16\text{mm}$. In the areas of the face where the anatomy was normal, differences on the overlaid images were very minimal indicating that good registrations of the two images had been obtained. However, the

overlaid images with and without the obturator in place showed large differences in facial form in the area where the obturator was present. When the obturator was in place there was a clear difference in facial form compared to when it was not in place with the area affected being clearly located in the region of the upper lip and extending bilaterally well beyond the limits of the nose. The colour coding additionally showed that the depth changes of the facial tissues in this area was considerable.

The final calculated surface areas that the obturators were restoring in each research participant are shown in Figure 2 as the mean of the four separate readings (registration 1, readings 1 and 2, and registration 2, readings 1 and 2). It can be seen that there is quite a wide range of outlined surface areas that appear to have been restored by the obturators in the different research participants. The exception was subject 7 in which there was very little effect overall. In relation to the surface area being restored the mean size of the outlined area when the obturators were present for the 19 research participants was 1411mm^2 ($\text{SD} \pm 848$, Range 52 - 3254mm^2).

The final calculated mean depth differences that the obturators were restoring in each research participant are shown in Figure 3 as the mean of the four separate readings (registration 1, readings 1 and 2, and registration 2, readings 1 and 2) for each research participant. Eleven of the nineteen research participants had mean depth differences of greater than 3mm. It can also be seen that research participant number 13, who is also shown in Figure 1, had the highest mean depth reading of 6.14mm. In relation to the depths being restored, the mean depth in the outlined area when the

obturator were present for the 19 research participants was 3.48mm (SD \pm 1.21, Range 1.61 - 6.14mm).

An inspection of Figures 2 and 3 together revealed some interesting observations for a number of the research participants. For example, in some individuals e.g. research participant numbers 1 and 6, a large surface area of defect is apparent with more modest mean depths. In others, e.g. research participant numbers 12 and 13, the obturator appears to restore a much smaller surface area but to a much greater mean depth.

The data from the OHIP-49 questionnaire was analysed particularly with reference to any issues that were raised about appearance. There is no specific theoretical dimension in the OHIP-49 for appearance. However the results of five questions from Table 1 which spanned four of the seven functional domains in the OHIP-49 questionnaire (functional limitation, psychologic discomfort, physical disability and psychologic disability) were of particular interest. Less than half of the research participants (47%) reported that they felt that their appearance was affected either fairly often or very often (Question 4). Indeed 37% of them reported that their appearance was either never or hardly ever affected. 63% of the research participants reported feeling self-conscious either fairly often or very often (Question 20). Only 26% of the research participants felt uncomfortable about their appearance either fairly often or very often (Question 22). 42% reported that they felt uncomfortable about appearance occasionally. In contrast, 79% of research participants reported that they never or hardly ever avoided smiling (Question 31), and only 21% reported feeling embarrassed either fairly often or very often (Question 38).

In relation to the questionnaire responses of individual research participants with the surface area and mean depth data there were some interesting observations. For example, in terms of surface area research participant number 4 had a defect at the smaller end of the scale which had been restored by the obturator. Generally, his responses to the quality of life questionnaires showed that overall he was very satisfied with aspects relating to the appearance (appearance hardly ever affected, never felt self-conscious, never felt uncomfortable about appearance, never avoided smiling, never felt embarrassed). Conversely the research participant already described in Figure 1 (research participant number 13 in subsequent bar charts) had a very large defect which had been restored by the obturator. Generally, her responses to the quality of life questionnaires showed that she was less satisfied with some aspects relating to the appearance (appearance affected very often, felt self-conscious very often, felt uncomfortable about appearance occasionally, hardly ever avoided smiling, felt embarrassed occasionally). There was a range of responses in other research participants. For example, research participant number 19 had a very large defect but reported that he never experienced issues in relation to all 5 questions. In contrast, research participant number 10 who had a more modest sized defect reported less satisfaction (appearance affected very often, felt self-conscious fairly often, uncomfortable about appearance very often, never avoided smiling, felt embarrassed fairly often). The Spearman's Rank Correlation Coefficients between each item on the OHIP-49 questionnaire and changes in surface area and mean depth are shown in Table 1. There was no significance found between either the changes in surface area or mean depth with the responses to individual items on the questionnaires.

DISCUSSION

This study has shown that obturators are clearly contributing to the restoration of facial form, both in relation to the surface area of the affected regions of the face and the depths by which unsupported facial tissues are displaced outwards when the prosthesis is in place. It was clear from the quality of life data that a proportion of research participants reported that they were affected by some issues related to their appearance. However, from the responses, many participants felt such effects only occasionally, hardly ever or never. Furthermore, in relation to all forty nine OHIP questions, no statistically significant evidence was found to directly relate the participants' responses on the quality of life questionnaires to the surface areas and mean depth changes of the facial tissues when the obturators were in place compared to when they were not.

In previous work where the technique of stereophotogrammetry was specifically developed to look at the effects of obturators, it was apparent that in the majority of the sample of individuals, clear volume changes were seen when the obturators were in place compared with when they were not [11]. The question however is would these volume changes be apparent to the research participants themselves as they are the individuals who see themselves both with the obturator in place and when it is not. Although volume changes are useful to determine objective effects of the obturators, from the perspective of the individuals they may well notice such effects on themselves in two ways. The first is by means of the area of the face that the insertion of the obturator impacts upon, and the second is how the depth of facial soft tissues that are unsupported by the surgical removal of bony structures will be displaced by

the obturator in a way which would restore a more acceptable facial appearance. For these reasons, in the present study it was possible to use the same difference images that were derived from the earlier study [11] to specifically calculate the surface area and depth differences for the research participants when their obturators were in place compared to when they were not. This would give additional information as to exactly how the obturators were contributing to the restoration of facial form and would also allow further exploration as to whether the surface area and depth changes were possible determinants to changed quality of life in relation to appearance for this group of research participants.

It had been found in a previous study [11], that the coefficients of repeatability of the measurements in relation to outlined areas on the difference images were of a significantly small magnitude to confirm that they would be clinically acceptable. For this reason, in the present study, the mean value of the four measurements was used to determine the effects of the obturators in restoring facial form, both in relation to surface area and depth measurements. Taking this into account, the data in Figure 2 show that in all but one of the research participants, the obturators were having a clear effect in relation to surface area on the face, and in a number of individuals these effects were very profound.

Similarly, the data on mean depth differences for the participants show clear effects from the obturator in displacing unsupported soft tissues of the face (Figure 3). In edentulous individuals, complete dentures can restore facial support in some areas such as the lips when the natural teeth have been lost. However, the bony structures of the maxilla and mandible will be intact. Individuals who have had large parts of

the maxilla removed will inevitably have more profound changes to their soft tissues than normal edentulous individuals. So, although some of the depth effects seen in this study could in part be accounted for by loss of the teeth, it is likely to be small in comparison to the effects of the obturator in supporting facial soft tissues affected by the more extensive surgical resections.

Taken together, these findings suggest that nearly all participants are likely to be well aware of the differences their obturators make to facial form, both in the area restored and the depth. Indeed, without the obturators in, it will be clear to them or anyone else that the facial tissues will be unsupported. This may particularly be the case with anterior resections such as the individual shown in Figure 1. In this research participant the obturator is having a very clear effect in supporting the facial tissues at large depths (Subject 13 in Figures 2 and 3), which, if the obturator was not in place would appear to drop back dramatically by as much as 10mm in places; a situation which would be very obvious indeed if the prosthesis was not being worn.

Despite there being objective data to show that obturators have effects on restoring facial contour, it is of interest to consider what the research participants reported in relation to the questions in which appearance would be expected to be a factor in their responses on the quality of life questionnaire. Although individuals reported effects on their quality of life in relation to the questions specifically where appearance was judged to be a factor, nevertheless quite a large proportion of them did not experience issues either fairly often or very often.

There are two aspects to consider in relation to these findings. The first is that a proportion of the individuals themselves may be very aware of their changed appearance when the prosthesis is not in place. Even though the obturators may be effective in restoring facial appearance, the individuals still have to cope with wearing them. Particularly with the large appliances, the individuals will often need to develop considerable oro-motor skills to keep them in place for oral function. This is particularly the case if the individuals are edentulous, but if some natural teeth remain in the mouth, they will potentially be of use in helping to provide support, retention and stability for the prostheses. For example, given the challenges of wearing such prostheses, this might explain the data that most individuals did not avoid smiling; if they have developed effective strategies by which the obturator is secure in function, they may well have no problem with the prosthesis dropping or displacing when carrying out this activity.

Breeze et al (2016) undertook a quality of life analysis before and after surgical treatment and demonstrated that individuals' quality of life did deteriorate after surgery, although there appeared to be no difference at one year in the responses between those who were rehabilitated using surgical flaps compared to those who wore obturators [8]. There may also be a range of other factors which might impact on quality of life. For example, radiotherapy may result in a range of short and long term effects including mucositis, lymphoedema, and reduced salivary flow as well as changes in relation to the senses of olfaction and taste. Some of these effects may impact on the individuals' ability to wear an obturator and function effectively with it. Indeed, in two previous studies it was found that postoperative radiotherapy was the strongest variable affecting quality of life for individuals who had undergone

maxillectomy procedures and were wearing obturators [2,9]. However due to limited research participant numbers it was not possible to explore this in a meaningful way for the present study in relation to the appearance related questions from the oral health related quality of life questionnaire.

The second aspect to consider in relation to the current findings is that even though the obturators may be effective in restoring the contour of the soft tissues, nevertheless a proportion of the research participants might be very aware that their appearance is still very much changed compared with how they looked before the surgery. They may not always wear the obturator, particularly when they do not have to interact socially, and be very conscious of their appearance when the prosthesis is not in place. Furthermore, if they perceive their appearance is altered and other functions are also affected such as speech, then this may well contribute to negative perceptions about embarrassment and being self conscious. It should also be noted that it would not be known as to whether the obturators were able to provide a similar level of facial support to that which existed prior to the surgical resections as discussed in more detail in a previous study [11]. One possible way to investigate this in the future would be to look at quality of life scores before and after treatment. However, notwithstanding the studies reported above in relation to quality of life, in any sequential use of oral health related quality of life questionnaires only limited information can be gathered unless some thought is given to the “minimally important difference” between before and after responses to determine a clinically significant response [20,21]. This would require further study.

Given that some of the area and depth changes of facial tissues with the obturators in place were profound compared to when they were not, it was considered possible that these effects might be directly related to scores from some of the appearance related items in the questionnaires. Indeed, for example there did appear to be less satisfaction reported by the research participant wearing the obturator restoring the larger defect (Figure 1). However, in other individuals the converse situation applied and examples have been described where one participant with a very large defect appeared very satisfied whilst another with a more modest defect appeared to report their quality of life being affected much more profoundly. Overall therefore, on the whole sample of participants, there was no evidence from the Spearman Rank Correlation Coefficients to support a clear link between the surface area and mean depth of the face that the obturator was impacting upon and the quality of life responses, both in relation to the items more closely related to appearance, as well as the other questions. There are two possibilities to consider in relation to these findings.

The first is that there is no certainty that the size of the defect that the obturator is restoring will directly impact on quality of life. Even though it might initially be considered that individuals who have the largest obturators will be affected to a greater degree than those who wear smaller ones, there are too many variables that might impact on this to draw any firm conclusions. For example some individuals may simply have developed greater oro-motor skills to wear their obturators more effectively than others. Alternatively, an obturator provided for an individual at one point in time might be more well made for their requirements than another made at a different time. In addition, some individuals might have more difficulties in wearing

even small obturators because of the effects of other components of their treatment e.g. radiotherapy resulting in reductions in salivary flow in one individual compared to another who has normal secretory function. There is also the question of response shift in which an individual might self-evaluate a particular outcome in a different way over time [22]. Therefore, an individual who may have worn their obturator for a prolonged period may report a reduced impact on quality of life compared to a response that they may have given when it was first fitted. The second consideration to explain why there was no clear link between the surface area and mean depth of the face that the obturator was impacting on with the quality of life responses is the possibility of Type II errors [18,19,23]. Sample size may be an issue [23] as it is always the case in studies such as this that relatively limited participant numbers will put constraints on the statistical comparisons that can be made. This is a difficult issue to address as even in this multi-centre study, the modest sample of participants that could be recruited to provide the data had to come from individuals who presented over a number of years, and who had undergone this type of treatment in three separate busy maxillofacial surgery units in the UK. Therefore, since the recruitment of individuals to achieve large sample sizes will always be an issue in relation to statistical power, given the relatively small numbers of people who present with these types of pathology in this anatomical region, to explore these effects further might therefore require a different approach – possibly by using in depth structured interviews to determine on a more individual basis the way in which participants may feel that their quality of life has changed and how exactly the obturators make a difference.

In conclusion, this study has shown clear changes in facial tissues, both in relation to surface area and depths of the affected regions of the face, after surgical removal of parts of the maxilla, when the research participants wear their obturators compared to when they are not in place. A proportion of these individuals seem to be affected by issues relating to their appearance, but conversely, another proportion seem to report such effects only occasionally, hardly ever or never. There is no simple relationship between the extent of facial change with and without an obturator in place, and quality of life experienced around issues relating to appearance. The determinants of changed quality of life in this group of patients require greater exploration.

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FIGURE LEGENDS

Figure 1. An example to show how facial images are used to determine the effect of a maxillary obturator on facial form in a research participant (number 13 in subsequent bar charts). A) the mark up for the registration process showing three views of the face from right, front and left sides. The hair neck, orbits and ears along with an area of the face beneath which the defect is situated have been shaded orange and eliminated from the registration process; B) the colour coded final difference image produced which allowed surface area and depth measurements to be calculated.

Figure 2. Bar chart to show the surface area of the restored facial defects for each research participant as defined by the outlines on the colour coded difference images.

Figure 3. Bar chart to show the mean depth differences of the restored facial defects for each research participant as defined by the colour coded difference images.

TABLE

Table 1. Spearman Rank Correlation Coefficients for the research participants' responses to the Oral Health Impact Profile (OHIP-49) questions and the surface area and mean depth measurements restored by the obturators. All correlation coefficients were non-significant.